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Seismic Analysis of G+10 Storey Building with Various Locations of Shear Walls using Etabs

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ABSTRACT
Shear walls are specially designed structural members provided in the multi-storey buildings to resist lateral forces. These walls have very high in-plane strength and stiffness, which can resist large horizontal forces and can support gravity loads. There are lots of literatures available to design and analyse the shear wall. However, what is the optimum location of shear wall in multi-storey buildings are not discussed extensively in any literature. It is very necessary to determine effective, efficient and ideal location of shear wall to get effective performance of the buildings. In this paper, therefore, main focus is to determine the efficient and effective location of shear walls in multi-storey buildings. In this paper, various models of G+10 storeyed building have been analysed by changing locations of shear walls for determining parameters like Base Shear, Lateral Displacement and Storey Drift. In this paper the Linear static method of analysis has been carried out on type-II soil (Medium soil sites) for a regular structure in plan in zone V for all the frame models and various load combinations are applied using software ETABS.The presence of shear wall can affect the seismic behaviour of frame structure to large extent, and the shear wall increases the strength and lateral stiffness of the structure. It has been found that the model M-09 having shear walls at the centroid of the building in cross shape (+ shape) shows better location of shear wall.

***KEYWORDS**: G+10 RC Building, Base shear, Storey Displacement, Storey drift, Equivalent Static Method*

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I. INTRODUCTION

Shear walls are one of the excellent means of providing earthquake resistance to multi-storeyed reinforced concrete buildings. When RC Multi-Storey building is designed without shear wall then beam, column sizes are quite heavy and steel required is large. So there is lot of congestion at the joints and it is difficult to place and vibrate concrete at these places. So Shear wall may become essential from the point of view of economy and control of horizontal displacement. The structure is still damaged due to some or the other reasons during earthquakes. Behaviour of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. To reduce the effect of earthquake, RCC shear walls are used in the buildings. These wall can be used for improving seismic response of multi-storey buildings. Structural design of buildings for seismic loading is primarily concerned with structural safety during major Earthquakes. In tall buildings, it is very important to ensure adequate lateral stiffness to resist lateral load. The provision of shear wall in building to achieve resistance against lateral forces due to wind and earthquakes. They are usually provided between column lines, in stair wells, lift wells and in shafts that house other utilities. Shear wall provide lateral load resistance by transferring the wind or earthquake load to the foundation. Besides, they impart lateral stiffness to the system and also carry gravity loads. When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system.

II. OBJECTIVE OF THIS STUDY

- To analyse different models with shear wall at different location using ETABS.
- To study various parameters like Base shear, Maximum Storey Displacement and Storey Drift.
- To find the effective and efficient location of Shear Wall.

III. METHODOLOGY

- Identification of thesis topic.
- Study and search literature review.
- Selection of method for analysis as follow-Equivalent static lateral force method.
- Selection of model parameter and software to be used for analysis.

IV. LITERATURE REVIEW

Shaik Akhil Ahamad, 2020 Studied that dynamic analysis of G+20 multi storied residential building provided with shear wall in various location for different seismic zones where done for determining the parameter like storey drift, base shear, maximum allowable displacement and torsional irregularity by adopting Response spectrum analysis. the analysis and modelling for the whole structure is done by using prominent FEM integrated software named ETAB in all the seismic zones of India prescribed by IS 1893 (Part-1) - 2016, in this project the dynamic analysis carried out on type -III (soft soil) for a irregular structure in plan in all the zones as specified and it is concluded that the structure with shear

wall that is case where building with shear wall at four corner ends placed symmetrically will show better results in terms of all the seismic parameters when compared with the structure without shear wall and with shear wall that is case having shear wall at one end.

Phadnis P.P and Kulkarni D.K 2013, In this paper they have studied G+3 and G+10 storey RCC frame of five different models with different shear wall configuration. The analysis has been carried out using ETABS and their analysis is based on equivalent static and response spectrum method carried out as per IS 1839-2002 (part-I) their seismic performance assessed by performing elastic time history analysis for the analysis recorded of the EL Centro, California earthquake .In this studied different parameter like Fundamental Natural Period, Lateral Displacement are determined.

Dodiya Jaimin et al (2018), Studied that G+20 multi-storey building with shear wall using ETAB software it determined the basic component like displacement and base shear this analysis has been carried using ETABS software for the analysis purpose Equivalent static method, Response spectrum method and Time history methods are adopted. It has been considered 4 different model with different configuration of shear wall and maximum displacement have been tabulated for each model and concluded the result for best configuration.

Eswaramoorthi P and Sylviya B (2018), Studied G+4 storey RCC frame which is subjected to Earthquake loading in different seismic zone and different model is there by changing the location of shear wall by using ETABS Seismic analysis performed by linear dynamic response spectrum method which is used to calculate the earthquake load as per IS 1893-2002 (Part I). Four different model like Structure without shear wall, structure with Shear wall at periphery, structure with shear wall at intermediate shear wall, structure with shear wall at core were model for analysis. The result has been calculated on the basis of parameter like storeydisplacement, storey shear and maximum storey displacement for each model It is studied the structural wall are most effective when placed at the periphery of the building.

V. STRUCTURE MODELLING

MODELING OF FRAME		
S.N	**Specification**	**Size**
GEOMETRY		
1	Slab thickness	0.125 m
2	Slab length along x direction	4.0 m
3	Slab length along y direction	4.0 m
4	No. of grid along x direction	7
5	No. of grid along y direction	9
6	Length of building along x direction	24.0 m
7	Length of building along y direction	32.0 m
8	Typical height of building	3.2 m
9	Bottom storey height	3 m
10	Number of storey	11
11	Total height of the building	35 m
12	Beam depth	0.450 m
13	Beam width	0.300 m
14	Column dimension along x	0.600 m
15	Column dimension along y	0.600 m
16	Thickness of shear wall	0.230 m
17	Inner wall thickness	0.115 m
18	Outer wall thickness	0.230 m
MATERAL PROPERTY		
1	Density of infill	18 KN/m^3
2	Density of concrete	25 KN/m^3
3	Grade of concrete	M-30
4	Grade of steel	Fe-415
SEISMIC DATA AS PER (IS1893-2016)		
1	Type of structure	OMRF
2	Soil type	Medium soil type(II)
3	Response reduction factor	5
4	Seismic zone factor Z	0.36
5	Importance factor	1
6	Damping of structure	5%

The 10-storeyed building frames consists of beams, columns, slabs and shear walls are modelled and analyse using software ETABS. Nine different models were studied with different positioning of shear wall for determining parameters like base shear, Storey displacement and storey drift to find out the best location of shear wall in buildings. Linear analysis have been done for all the 9 models each model consist of constant total length of 32 m. Floor plans and 3d view of all the models are shown below:

Model definition-

Table 01 Model definition

Model name	Notation of Model	Model description
Model-01	M-01	Building without any shear wall – Conventional frame
Model-02	M-02	Building with shear wall at periphery at four corners.
Model-03	M-03	Building with shear wall at intermediate corner.
Model-04	M-04	Building with shear wall at centre way periphery.
Model-05	M-05	Building with shear wall at intermediate centre way.
Model-06	M-06	Building with shear wall at core.
Model-07	M-07	Building with shear wall in cross shape longer in x direction
Model-08	M-08	Building with shear wall in cross shape longer in y direction
Model-09	M-09	Building with shear wall in cross shape equal length on both direction.

Plan and 3d view of all 9 model –

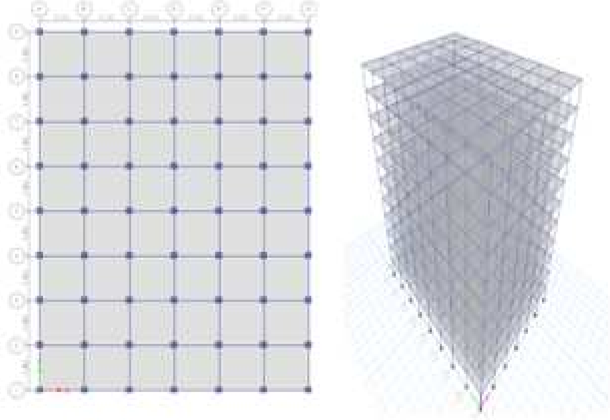


Fig.1M-01

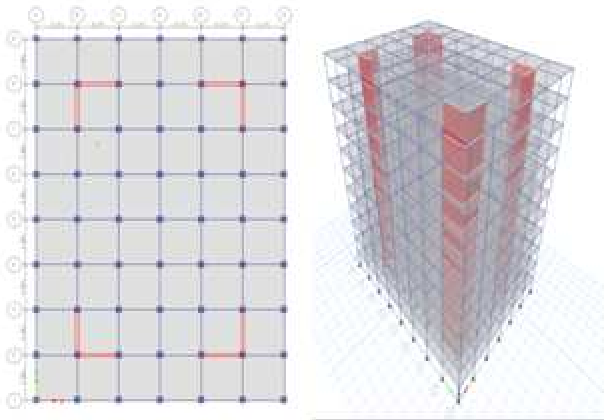


Fig.3M-03

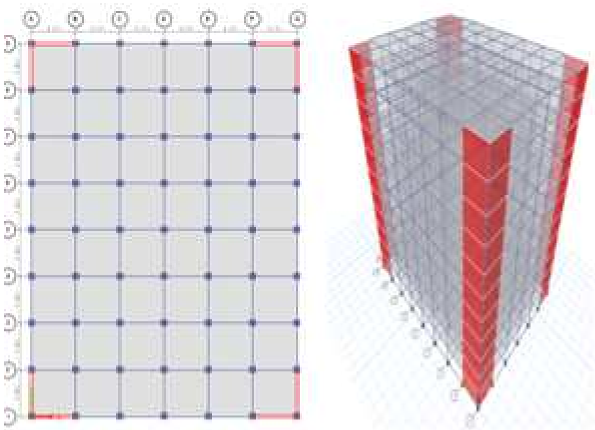


Fig.2M-02

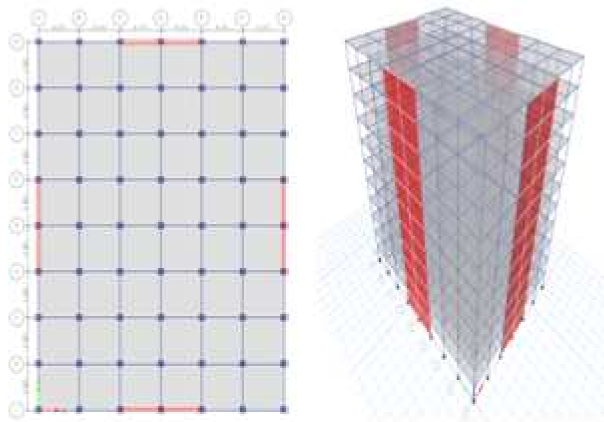


Fig.4M-04

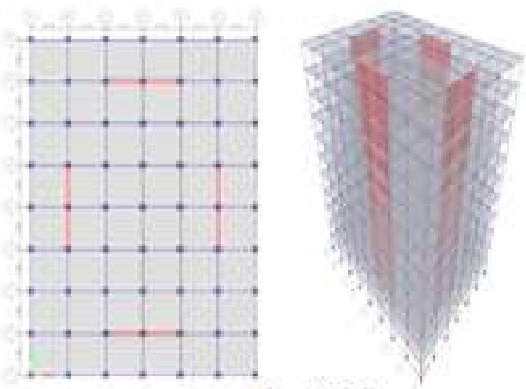


Fig.5M-05

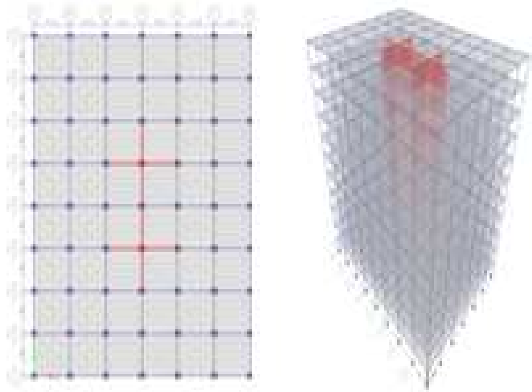


Fig.8M-08

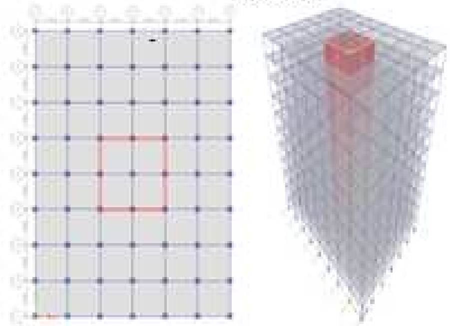


Fig.6M-06

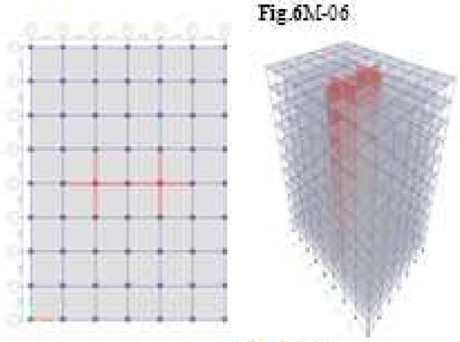


Fig.7M-07

Fig.8M-08

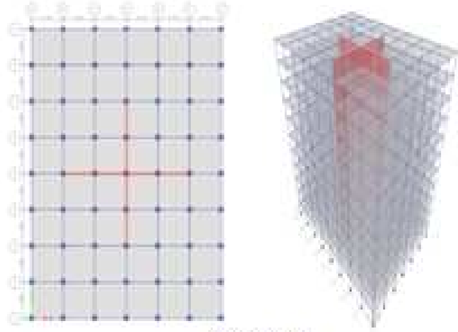
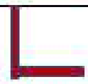
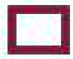
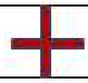


Fig.9M-09

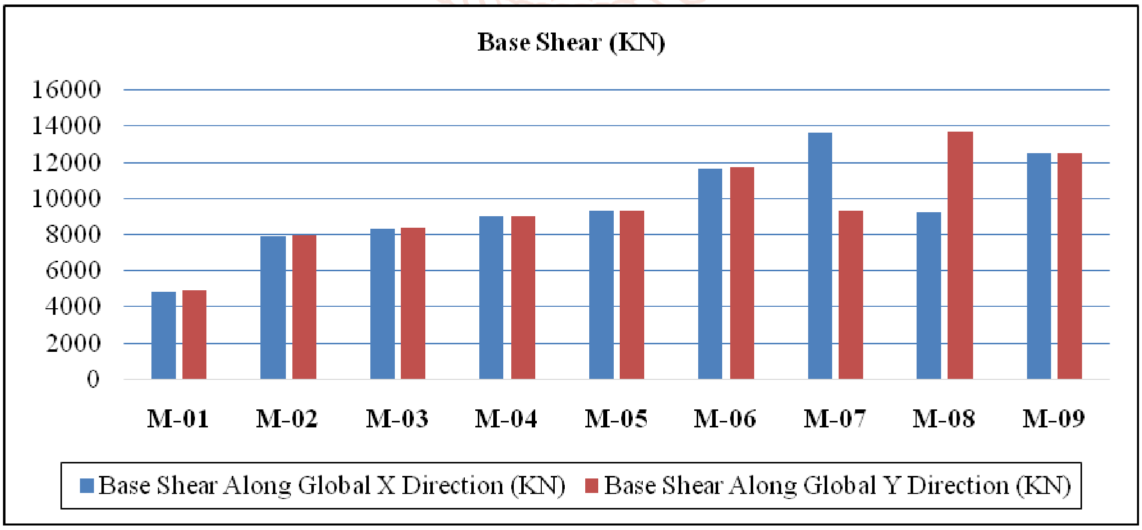
Table-2 Different shape use in this paper for shear wall		
1.	Rectangular shape	
2.	L- shape	
3.	Box shape	
4.	Cross shape	

RESULT AND DISCUSSION

Among all the load combination, the load combination of 1.5DL+1.5EQ is found to be the most critical combination in both X and Y directions for all the models. All the results are for load combination of 1.5DL+1.5EQ, where DL= Dead load including floor finish load and wall load, and EQ= Earthquake load in corresponding direction. Obtained results have been presented in form of graphs, indicating the trends and pattern of variables such as Base shear, lateral displacement, storey drift.

1. Base shear

Model Name	Base Shear Along X(KN)	Base Shear Along Y(KN)
M-01	4860	4915
M-02	7925	7978
M-03	8330	8374
M-04	9017	9064
M-05	9293	9339
M-06	11677	11712
M-07	13684	9309
M-08	9263	13722
M-09	12501	12547

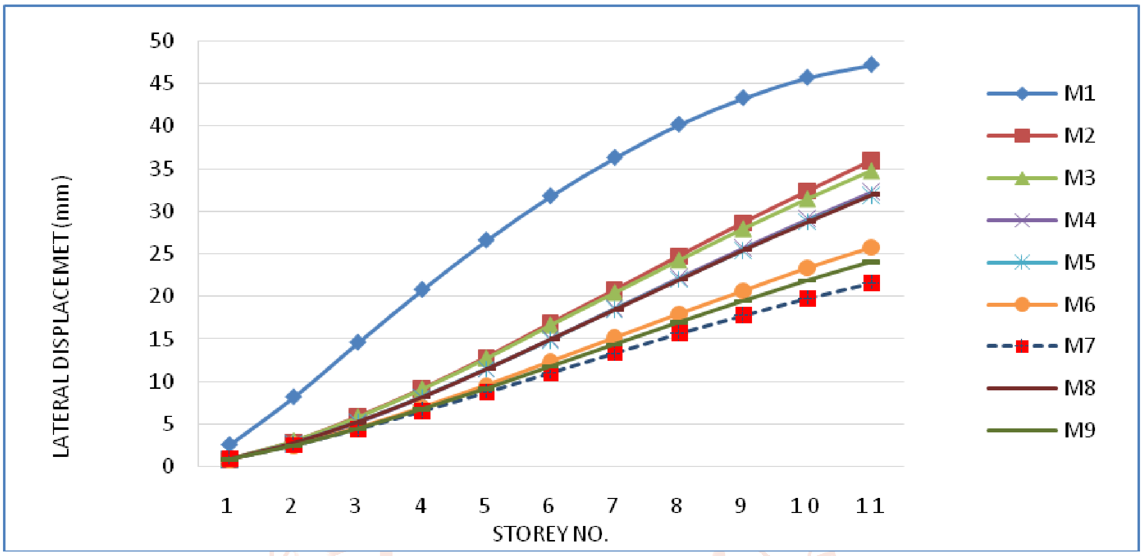


The value for the base shear is maximum for model M-07 along X axis and for Model M-08 along Y axis and for Model M-09 is nearly same along both the axis.

2. Storey Displacement (mm)

➢ Along X axis

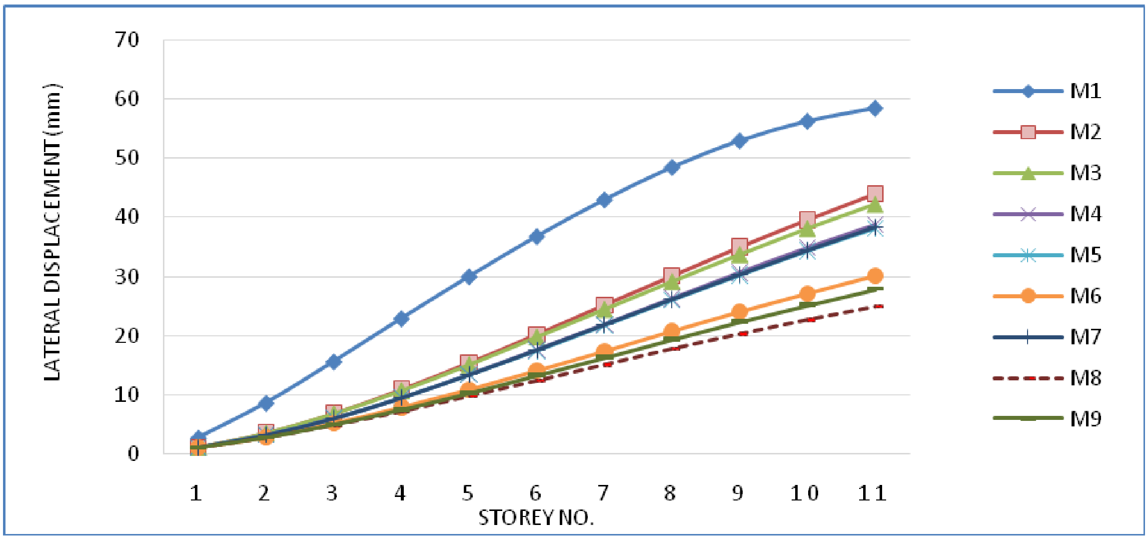
Storey displacement (mm) along X axis										
Storey No.	Storey height from ground (m)	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
11	35	59.4	44.3	42.4	39.1	38.4	30.2	24.8	38.5	27.9
10	31.8	57.1	39.8	38.3	35.1	34.5	27.2	22.7	34.6	25.2
9	28.6	53.6	35.1	33.9	30.8	30.4	24.1	20.3	30.5	22.4
8	25.4	49.0	30.2	29.3	26.5	26.1	20.8	17.7	26.2	19.4
7	22.2	43.5	25.2	24.5	22.0	21.8	17.4	15.1	21.9	16.3
6	19	37.2	20.2	19.7	17.6	17.5	14.0	12.4	17.5	13.2
5	15.8	30.3	15.3	15.1	13.4	13.3	10.8	9.7	13.3	10.2
4	12.6	23.1	10.8	10.6	9.4	9.4	7.8	7.1	9.4	7.4
3	9.4	15.8	6.8	6.7	5.9	5.9	5.1	4.8	6.0	4.9
2	6.2	8.7	3.4	3.4	3.1	3.1	2.7	2.7	3.1	2.7
1	3	2.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



The maximum lateral displacement was obtained on the top floor level in each model which was reduced by 25.4% in model M2, 28.5% in model M3, 34.20% in model M4, 35.40% in model M5, 49.10% in model M6, 58.10 % in model M7, 35.1% in model M8, 53.0% in model M9 as compared to the model Ml (conventional model).

➢ Along Y axis

Storey displacement (mm) along Y axis										
Storey No.	Storey height form ground (m)	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
11	35	58.5	43.9	42.2	38.8	38.1	30.1	38.3	24.8	27.8
10	31.8	56.3	39.5	38.1	34.9	34.3	27.1	34.4	22.6	25.1
9	28.6	53.0	34.9	33.7	30.7	30.2	24.0	30.3	20.2	22.3
8	25.4	48.5	30.0	29.1	26.3	26.0	20.7	26.1	17.7	19.3
7	22.2	43.0	25.1	24.4	21.9	21.7	17.3	21.8	15.0	16.2
6	19	36.8	20.1	19.7	17.6	17.4	14.0	17.5	12.3	13.2
5	15.8	30.0	15.3	15.0	13.4	13.3	10.8	13.3	9.7	10.2
4	12.6	22.9	10.8	10.6	9.4	9.4	7.8	9.4	7.1	7.4
3	9.4	15.6	6.7	6.7	5.9	5.9	5.1	5.9	4.8	4.9
2	6.2	8.6	3.4	3.4	3.1	3.1	2.7	3.1	2.7	2.7
1	3	2.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

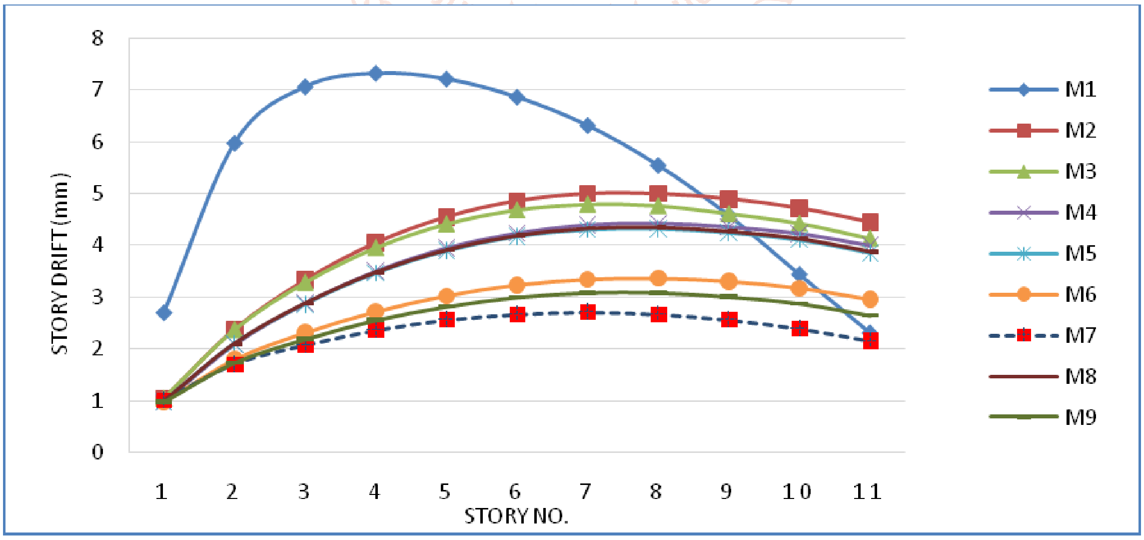


The maximum lateral displacement was obtained on the top floor level in each model which was reduced by 25% in model M2, 28% in model M3, 33.7% in model M4,34.9% in model M5, 48.6% in model M6, 34.6% in model M7, **57.7% in model M8**,52.6% in model M9as compared to the model Ml (base model).

3. Storey drift (mm)

➢ Along X Axis

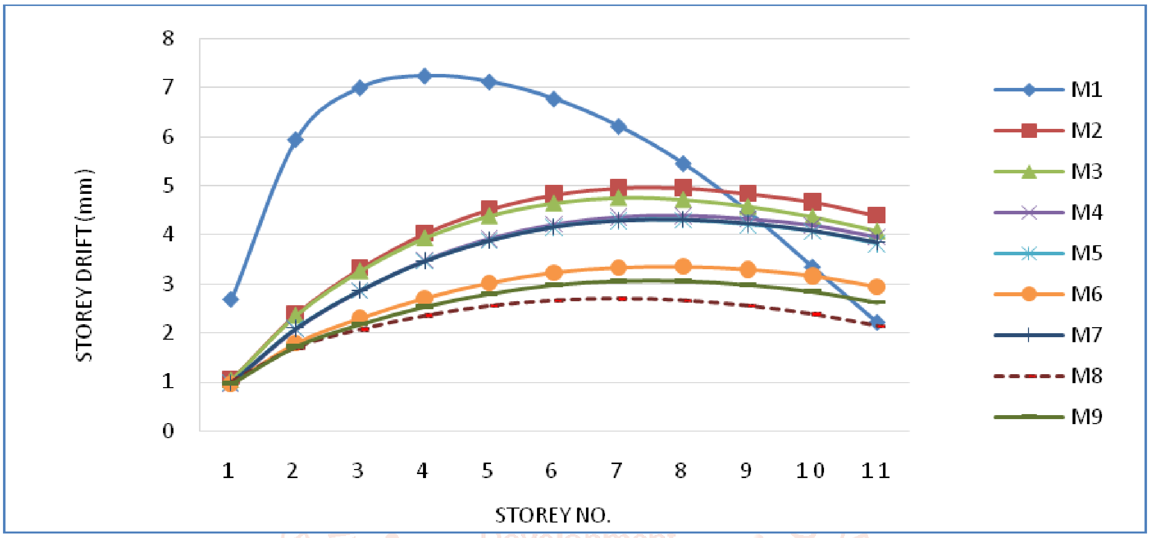
Maximum storey Drift (mm) along X axis										
Storey No.	Storey height from ground (m)	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
11	35	2.31	4.45	4.13	4.00	3.86	2.96	2.15	3.88	2.64
10	31.8	3.44	4.72	4.42	4.23	4.11	3.18	2.39	4.13	2.87
9	28.6	4.58	4.90	4.61	4.36	4.25	3.31	2.56	4.27	3.00
8	25.4	5.55	5.00	4.76	4.43	4.33	3.37	2.67	4.35	3.08
7	22.2	6.32	5.00	4.79	4.40	4.31	3.35	2.71	4.33	3.08
6	19	6.87	4.86	4.68	4.24	4.18	3.24	2.67	4.19	2.99
5	15.8	7.22	4.55	4.41	3.95	3.90	3.03	2.56	3.91	2.81
4	12.6	7.33	4.05	3.95	3.50	3.47	2.72	2.36	3.48	2.55
3	9.4	7.07	3.33	3.28	2.88	2.87	2.31	2.07	2.88	2.18
2	6.2	5.98	2.38	2.37	2.09	2.10	1.79	1.70	2.10	1.73
1	3	2.70	1.04	1.04	0.97	0.98	0.96	1.00	0.98	0.97



The maximum storey drift was reduced by 61.62% in model M2, 61.29% in model M3,65.01% in model M4, 64.95% in model M5, 70.04% in model M6**, 71.59% in model M7**,64.59 % in model M8, 71.05 % in model M9 as compared to the model Ml (base model).

➢ Along Y Axis

Storey Drift (mm) along Y axis										
Storey No.	Storey height from ground(m)	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9
11	35	2.22	4.39	4.08	3.96	3.82	2.94	3.85	2.14	2.62
10	31.8	3.35	4.67	4.37	4.20	4.07	3.16	4.09	2.38	2.84
9	28.6	4.48	4.84	4.58	4.33	4.21	3.29	4.24	2.55	2.98
8	25.4	5.46	4.96	4.72	4.40	4.30	3.35	4.32	2.66	3.06
7	22.2	6.22	4.96	4.76	4.37	4.29	3.33	4.30	2.70	3.06
6	19	6.78	4.82	4.65	4.22	4.16	3.23	4.17	2.66	2.98
5	15.8	7.13	4.52	4.39	3.93	3.88	3.02	3.89	2.55	2.80
4	12.6	7.25	4.03	3.94	3.49	3.46	2.71	3.47	2.35	2.54
3	9.4	7.01	3.32	3.27	2.87	2.86	2.30	2.87	2.07	2.18
2	6.2	5.95	2.38	2.36	2.09	2.09	1.79	2.09	1.70	1.73
1	3	2.69	1.04	1.04	0.97	0.98	0.96	0.98	1.00	0.97



The maximum storey drift was reduced by 61.54 % in model M2, 61.20 % in model M3, 64.85% in model M4, 64.85% in model M5, 69.91% in model M6, 64.80 % in model M7,**71.42% in model M8**, 70.94% in model M9 as compare to Model M-01.

VI. CONCLUSION

The analytical study on various shear wall configurations is done by creating a model for each configuration and the base shear, lateral displacement and storey drift for various models are obtained. Among all the load combinations, the load combination of 1.5DL+1.5EQ is found to be the most critical combination in both X and Y direction for all the models. From the study, the following conclusions can be drawn out:

1. From the result of base shear it has been observe that maximum value of Base Shear for Model – 07 along Global X direction and Model-08 along Global Y direction which consist of Shear wall in cross shape at core this is due to higher stiffness along the length of shear wall and minimum for model M-01(without shear wall) so we conclude that due to presence of shear wall the base shear increases.
2. From the linear static analysis it has been found that model M-2 and M-4 having shear wall outward the centroid of building shows large lateral displacement and storey drift along both x and ydirection compared to Model M-3, M-5, M-6 and M-9 having shear wall towards the centroid of the building from this we conclude that shear walls provided at centre gives better and efficient result.
3. From the analysis of story drift and story displacement it has been found that it follow the same pattern or nearly coincide with each other for model M-4, M-5, M-8 along X axis and model M-4, M-5, M-7 along Y axis.
4. It has been found that in model M-2 and M-3 having L shape shear wall shows large lateral displacement and storey drift as compared to other models having rectangular shape shear wall so we conclude that building with shear walls having rectangular shape gives better result as compared to other shapes used in this paper due to large length available along seismic force direction which gives high stiffness.
5. The presence of shear wall can affect the seismic behaviour of frame structure to large extent, and the shear wall increases the strength and lateral stiffness of the structure. It has been found that the model M-09 having shear walls at the centroid of the building in cross shape (+ shape) shows better location of shear wall.

Scope of Future Work

There is a scope of extending this work to include the following for future:-

1. The present work has been carried out to find the effective position and configuration of shear walls in a symmetric building. The work can be extended to asymmetric buildings.

2. In this study ETABS 2016 has been used; other softwares like STAAD Pro, SAP, ANSYS etc can be used.
3. Here linear static and linear dynamic (response spectrum method) have been performed other nonlinear analysis like time history and Push over analysis can be done for same building

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